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ABSTRACT

One way to achieve a higher level of agreement on the nature of science (NOS) within the science education community is to embrace the two major documents, Benchmarks for Science Literacy (1993) and National Science Education Standards (1996). Both Benchmarks and Standards have many statements on the nature of science that can be used as the basis for research in this area of science literacy. This paper reports a study of the development and field test of a questionnaire based on the NOS information in Benchmarks and Standards. (WRM)

NATURE-OF-SCIENCE ASSESSMENT BASED ON *BENCHMARKS* AND *STANDARDS*

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One way to achieve a higher level of agreement on the nature of science (NOS) within the science education community is to embrace the two major reform documents, Benchmarks for Science Literacy (1993) and National Science Education Standards (1996). Both Benchmarks and Standards have many statements on NOS that can be used as the basis for research in this area of science literacy. This paper reports a study of the development and field test of a questionnaire based on NOS information in Benchmarks and Standards.

Problems with NOS Research

The nature of science is complex; as philosophers, historians, and sociologists of science have reminded us in recent decades. Long before Kuhn's The Structure of Scientific Revolutions appeared in 1962, there was vigorous discussion among academics about scientific knowledge and how it is achieved. However, The Structure... raised the intensity of the debate and caused many more persons to become involved, including many in the science education research community. This debate has become more vigorous in recent years.

In science education, NOS research has been done by individuals who have various ideas about the nature of scientific knowledge and how it is generated; however, until recently there

has been little opportunity to achieve much agreement. Each researcher developed a questionnaire that reflected his or her own ideas about NOS, resulting in data sets that are difficult to compare. A recent historical study (Lederman et al., 1998) identifies 25 questionnaires developed since 1954 that purport to assess ideas and attitudes on science. An earlier, very comprehensive (480 pages) report by Munby (1983) gave detailed descriptions and critiques of 56 instruments designed to assess ideas and attitudes on science.

We want to focus on the importance of using consensus documents like Benchmarks (1993) and Standards (1996) as the first step to improving NOS research in the science education research community. Until Benchmarks (1993) and Standards (1996) appeared, there seemed to be little chance that any kind of consensus on NOS could be reached within the science education community. Now there is at least some chance that these documents will help science education researchers reach greater agreement on this complex construct and, perhaps, find more reliable and valid ways to measure achievement in this area of science literacy.

There are other problems in doing NOS research, such as relying too heavily on questionnaire data, but these will be treated only briefly in the last section of this paper. A recent (November 1998) special issue of Science & Education contains many ideas on the nature of science and science education that are well worth considering in order to avoid certain problems in NOS research. We want to focus here on the importance of using consensus documents like Benchmarks and Standards as the first step to improving NOS research in the science education

research community. There is an important distinction that we want to make here between attitude toward and understanding of science, before we describe our own efforts to design and test the Ideas on Natural Science instrument. Many of the instruments described in Munby (1983) include both attitude and understanding items. We are interested primarily in assessing understanding about science not attitude toward it, even though that distinction is sometimes a bit fuzzy.

Development of Instrument

Developing NOS Items

Most of the 28 items in the questionnaire Ideas on Natural Science (Appendix A) used to collect data reported in this paper were drawn from the first chapter of Science for All Americans, (SFAA) (1990), the precursor of both Benchmarks and Standards. In some cases (e.g., items 1,3,4,5,6,7,10) items are the same or very nearly the same as they appear in SFAA and in other cases (e.g., items 2,8,9,11,12,13,14,16,17) the items follow closely from the content of SFAA, but the wording is changed. The remaining items (18-28) are consistent with the content of SFAA, Benchmarks, and Standards, but the wording of the items may differ quite a bit.

We are aware that the wording of a question or statement can have a big effect on how a

respondent interprets the item, a problem faced by all researchers who rely on questionnaire data to answer research questions. The 'mechanics' of developing a good questionnaire are complex and we do not want to underestimate their importance. However, our main purpose in this paper is to focus attention on using the main reform documents to achieve greater agreement on the nature of science.

Grouping NOS Items

Many groupings are possible for the 28 items in this NOS questionnaire, and seven are suggested here:

1. About nature
2. How scientific knowledge grows
3. Validity and reliability of science knowledge
4. Scientific method
5. Science vs. technology
6. Scientists as people
7. Science and nonscience

Most of the items and the categories or groupings involve matters of epistemology. A few of the items (e.g., 1, 2 &3) and two categories (1&7) include aspects of the nature of reality. The

boundaries of the groupings are not sharp; an item may seem to fall within two categories but we have 'forced' each item into one category only:

Group 1: Items 1, 2, 3, 5

Group 2: Items 4, 6, 13, 14, 19, 23

Group 3: Items 10, 21, 22, 28

Group 4: Items 8, 9, 11, 26

Group 5: Items 18, 27

Group 6: Items 15, 16, 17, 24, 25

Group 7: Items 7, 12, 20

For better or worse, we use these categories as a way to define 'nature of science'. If our main proposal (use Benchmarks and Standards to develop NOS research items) is accepted by the science education research community, we are confident that more groupings and many more items will be developed and used in future NOS research. Our efforts reported in this paper are only a modest beginning in that direction.

Field Testing The Instrument

The questionnaire was given to 5 classes covering 3 content preparations. Three of the preparations were in education, and two were in chemistry.

The Fall 1997 Study: Critical Issues Class

The 28-item INS questionnaire was developed early in the fall semester and administered to a "Critical Issues in Science" class of 15 preservice and inservice secondary science teachers (12 females and 3 males). This class is at the senior level and can be taken by both undergraduate and graduate students. It is a required course for the undergraduate certification program. For each item they circled 'agree' or 'disagree' and then explained why they believed their choice was correct. The class met once a week for 3 hours, and the week following the administration of the questionnaire about an hour of class time was devoted to discussing their choices and potential problems with the questionnaire. The results from the questionnaire are shown in Table 1.

On sixteen of the twenty-eight items at least 70% of the students selected what the authors considered to be the correct choice. Of the remaining thirteen items, students had low agreement (less than 55% correct) on items 2, 3, 7, 12, 20, 21 and 27 for a total of seven items. Items 2 and 3 involve assumptions about the universal nature of Nature, items 7, 12 and 20 are statements about the limits or domain of science, and item 21 taps the students' beliefs about the reliability of science knowledge. To the extent that a numerical score has meaning here, the average score was 20 out of 28. During discussion of the questionnaire, students who disagreed with the 'correct' response often did so for reasons involving the precise meaning of a word, such as 'confident', 'assume', 'usefully', and 'reliable'. The source of disagreement often seemed to be more about semantics than about fundamental (mis)understandings of the nature of science.

This does not mean that differences among the students did not exist; however, much of the disagreement seemed to originate in the interpretation of words in the questionnaire. Relying solely on a questionnaire to assess students' NOS ideas is a risky business.

Table 1. Student responses to the INS questionnaire.

Question	Correct Response	Percent Correct
1	A	92.8
2	A	53.3
3	A	53.3
4	A	78.6
5	A	100
6	A	85.7
7	A	50.0
8	A	93.3
9	A	61.5
10	A	64.3
11	A	69.2
12	A	26.7
13	A	93.3
14	A	93.3
15	D	100
16	D	100
17	A	84.6
18	D	80.0
19	A	100
20	A	50.0
21	D	50.0
22	D	86.7
23	D	64.3
24	D	100
25	D	73.3
26	D	85.7
27	D	26.7

28	D	61.5
	Average	74.2

The Summer and Fall 1998 Studies: Science Methods Classes

The questionnaire was given to two classes of "Reflective Teaching: Science," which is a methods course for the teaching of science. One of the classes was taught in the summer of 1998 and the other in the fall of 1998. The classes were taught by two different instructors, but the instructors met before the summer class to discuss content to be covered. The summer class met twice a week for 2 hours each session, and the fall class met once a week for 3 hours. Obviously the field component of the courses differs greatly due to the lack of regular, formal school settings in the summer. The classes were composed of both preservice and inservice secondary science teachers. This class is at the senior level and can be taken by both undergraduate and graduate students. It is a required course for the undergraduate certification program, the graduate certification program (Holmes Group), and the alternate certification program (students with degrees in other fields taking coursework to be certified). The Holmes Group students only take the class in the summer. Because of the many differences between the two classes, and the small sample sizes involved, in-depth analysis between the two groups will not be addressed in this paper. Demographic data taken for the students can be found in Table 2.

The questionnaire was given to the students on the first day of class and was to be returned on the second class meeting. For each item the students circled 'agree' or 'disagree' and then explained why they believed their choice was correct. The concepts in the questionnaire

Table 2. Demographic data of Science Methods Classes

Characteristic		Summer 98	Fall 98
Sex			
	Female	8	9
	Male	3	3
Program			
	Traditional Program	3	5
	Holmes Program	3	0
	Alternative Certification	4	7
	Other	1	0

were stressed throughout the class as the Standards were a required text for the course. The results from the questionnaire are shown in Table 3.

For the summer 1998 course, on thirteen of the twenty-eight items, at least 70% of the students selected what the authors considered to be the correct choice, as compared to the "Critical Issues" class' sixteen. Of the remaining fifteen items, students had low agreement (less than 55% correct) on items 2, 3, 6, 7, 9, 12, 20, 22 and 27 for a total of nine items compared to the "Critical Issues" class' seven. For the fall 1998 course, on thirteen of the twenty-eight items, at least 70% of the students selected what the authors considered to be the correct choice, which also made the number of items thirteen as compared to the "Critical Issues" class' sixteen. However, the individual items in this set of items are not identical to the summer 1998 results.

Of the remaining fifteen items, students had low agreement (less than 55% correct) on items 2, 3, 9, 12, 20, 27, and 28 for a total of seven items compared to the "Critical Issues" class' seven. Again however, the individual items in this set of items are not identical to the fall 1998 results. Across all three groups, it appears that items 5, 8, 13, 15, 16, 17, 19, 23, and 24 have the highest frequency of correct answers, while items 2, 3, 12, 20, and 27 have the highest frequency of incorrect answers.

The Fall 1998 Study: Chemistry Courses and some interpretation of what the instrument tells us

The survey was administered to 161 students in two different college-level chemistry courses. 97 students in the first semester of a general chemistry course and 64 students in a one-semester organic chemistry class participated.

The general chemistry course is designed for the science and engineering curricula, and is described in the university's general catalog as a study of "modern chemical theory and principles; quantitative approach and problem solving; descriptive chemistry of selected elements and compounds." Most of the students surveyed in this class were freshmen, with 51 males and 46 females participating. These students were primarily enrolled in the colleges of engineering, arts and sciences, and agriculture; however, a large number of students did not report choosing a college.

The one-semester organic chemistry course is described in the general catalog as covering "aliphatic and aromatic compounds; biological aspects of organic chemistry." 40 females and 24

males were surveyed, most of who were sophomores or juniors enrolled in the agriculture college. A synopsis of some characteristics of these students is given in Table 4.

Table 3. Responses of students to the survey.

Question	Correct Response	Percent Correct Summer 98	Percent Correct Fall 98
1	A	63.6	58.3
2	A	27.3	41.6
3	A	27.3	29.2
4	A	90.1	58.3
5	A	90.1	91.7
6	A	54.6	66.7
7	A	45.5	58.3
8	A	90.1	100
9	A	45.5	25.0
10	A	63.6	58.3
11	A	72.7	66.7
12	A	27.3	33.3
13	A	90.1	83.3
14	A	63.6	79.1
15	D	90.1	100
16	D	72.7	83.3
17	A	81.8	83.3
18	D	72.7	66.7
19	A	100	91.7
20	A	36.4	16.7
21	D	72.7	66.7
22	D	54.5	75.0
23	D	81.8	83.3
24	D	72.7	91.7
25	D	63.6	83.3
26	D	63.6	83.3

27	D	18.2	8.3
28	D	68.2	37.5
	Average	59.1	65.0

Table 4. Characteristics of chemistry students surveyed.

Characteristic		General Chemistry	Organic Chemistry
Sex			
	Female	46	40
	Male	51	24
Grade Level			
	Freshman	82	1
	Sophomore	9	20
	Junior	3	26
	Senior	1	13
	Graduate	3	1
	Not Reporting	1	1
Age			
	19 - 25	91	54
	26 - 30	3	2
	30 - 35	2	6
	36 -	0	2
	Not Reporting	1	2
College of Declared Major			
	Agriculture	12	50
	Arts and Sciences	17	1
	Business Administration	2	0
	Design	0	

Education	1	2
Engineering	23	1
General College	8	2
Mass Communication	0	0
Music	0	0
Not Reporting	34	8

A summary of student responses to the survey questions is given in Table 5. The mean score of the freshman chemistry class on the survey was 17.0 out of 28 questions (60.8%) with a standard deviation of 2.67 and reliability (KR-20) of 0.214. Two students received the highest score, 23 out of 28 (82.1%), and a single score of 9 correct (32.1%) represented the low score in this class. The mean score of the organic chemistry class on the survey was 17.5 out of 28 questions (62.4%) with a standard deviation of 2.70 and reliability (KR-20) of 0.276. Four students received the highest score, 22 out of 28 (78%), and a single score of 10 correct (35%) represented the low score in this class. Consistent with the low reliability is the fact that for two questions administered to the organic chemistry class, students scoring in the lower third overall received higher scores than students scoring in the upper third. This occurred with item 12 and item 15.

In reporting our final study, which has the largest sample size, we will also look at the groupings mentioned earlier and how the data might be analyzed according to these groupings. Related to our Group 1, which considers understandings of Nature, many students appear to disagree about the concept of universality. The statement "Scientists assume that the universe is a vast single system in which the basic rules are the same everywhere" (item 3) generated agreement among only 63.9% of freshmen and 64.1% of organic students. Only an overall minority agreed that "Scientists are confident they can discover patterns in all of nature" (item 2)

Table 5. Responses of students to the survey.

Question	Correct Response	Percent Correct Freshmen	Percent Correct Organic
1	A	84.5	85.7
2	A	55.7	48.4
3	A	36.1	35.9
4	A	81.4	82.8
5	A	84.5	96.9
6	A	59.8	70.3
7	A	62.9	62.5
8	A	72.2	70.3
9	A	18.6	18.8
10	A	76.3	68.8
11	A	60.8	75.0
12	A	43.3	45.3
13	A	69.1	73.4
14	A	83.5	87.5
15	D	89.7	89.1
16	D	59.8	60.9
17	A	69.1	75.0
18	D	43.3	43.8
19	A	84.5	85.9
20	A	33.0	20.3
21	D	58.8	65.6
22	D	56.7	53.1
23	D	76.3	78.1
24	D	74.2	84.4
25	D	51.5	50.0
26	D	49.5	59.4
27	D	15.5	10.9
28	D	50.5	59.4
	Average	60.8	62.8

(44.3% of freshman and 51.6% of organic students).

The Group 2 items deal with how scientific knowledge grows, and overall the students did well in this grouping. 83.5% of freshman and 87.5% of organic students agreed that "Theories in science must be logically or mathematically sound and use a significant body of valid observations" (item 14). These students were also in agreement that "Change and conformity are persistent features of science" (item 19) (84.5% and 85.9%, respectively). The related statement that "Continuity and stability are as characteristic of science as change is, and confidence is as prevalent as tentativeness" (item 6) generated slightly less agreement (59.8% and 70.3%, respectively).

Items in Group 3 deal with validity and reliability in science. In spite of this substantial agreement as to how theories should be developed, almost half of the students in each group (42.8% of freshmen and 46.9% of organic students) agreed that "The word 'theory' in science means a hunch or guess about how some part of the world works" (item 22).

Apparently, most of these students view science as a process with a set of directions. This refers to items in Group 4. It is likely that few of these students have been exposed to scientific research; rather, it is more likely that their views of science are largely based on exposure to science lectures in which they repeatedly are shown step-by-step procedures that lead to successful developments in science. Most participants (81.4% of freshmen and 81.2% of organic chemistry students disagreed with the statement "There is no fixed set of steps that

scientists follow that leads them to scientific knowledge" (item 9). Also, while we disagree that science is only done by using controlled experiments (item 26), 50.5% of freshmen and 40.6% of organic students agreed with this statement.

When we look at the items in our Group 5, it appears that the distinction between science and technology to these students is unclear. A majority of students in both groups (56.7% of freshmen and 56.2% of organic students) agreed that "The purposes of science and technology are about the same" (item 18)". The single statement receiving the lowest score in both classes was item 27, which said that "most scientific discoveries are useful to people." Although we consider that the correct response to this statement is "no," 84.5% of freshman chemistry students and 89.9% of organic chemistry students agreed with this statement.

In relation to our Group 6, these students appear to hold scientists and their ability to judge and reason in high regard. Roughly half of the participants (48.5% of freshmen and 50.0% of organic chemists) agreed with the statement "A scientist is more willing to change her mind when new evidence appears than are other people" (item 25). Although the majority of subjects recognized that scientists could be biased in matters not pertaining to science, a substantial minority disagreed with the statement "Scientists are less likely to be biased in public matters that are other members of society" (item 16) (40.2% of freshman and 39.1% of organic students). And although most scientists were seen as behaving in an ethical manner within their profession, a notable minority (30.9% of freshmen and 25.0% of organic students) disagreed with the

statement "The vast majority of scientists stay within the bounds of ethical professional behavior" (item 17).

Distinguishing between science and nonscience is our Group 7. Only 43.3% of the freshman chemistry students and 45.3% of the organic chemistry students, agreed with the statement "A hypothesis that cannot in principle be put to the test of evidence is not scientifically useful" (item 12). In light of this answer, it may not be surprising that few students (33.0% of freshman and 20.3% of the organic students) agreed that "Supernatural explanations of natural phenomena have no place in science" (item 20).

As a summary to this section on results of administering the INS to two chemistry classes, we compare the 7 groupings by ranking them in terms of "easiest" to "most difficult" for the students. Table 6 shows that grouping 2 (How scientific knowledge grows; items 4,6,13,14,19,23) are easiest for the students while grouping 7 (Science and nonscience; items7,12,20) is the most difficult.

Table 6. Relative difficulty of the 7 INS groupings (chemistry sample).

Grouping (name)	% Correct
2 (How scientific knowledge grows)	80.4
1 (About nature)	65.8
3 (Validity & reliability of science knowledge)	61.0
6 (Scientists as people)	56.4
4 (Scientific method)	52.5
5 (Science vs. technology)	48.4
7 (Science and nonscience)	42.9

Only for grouping 2 can it be said that students have a reasonably good grasp of that aspect of the nature of science. Groupings 5 & 7 are closely related in that both are asking for ideas about the domain of science. Analysis of subscales or groupings of similar items within a test provides information that can help a teacher decide where more emphasis is needed. For these data it is fairly clear that students do not differentiate between science and nonscience.

Conclusions

Nature-of-science research needs to have reasonable agreement among researchers regarding the nature of science; otherwise we will continue to use data collection instruments that are difficult to compare. Benchmarks for Science Literacy (1993) and National Science Education Standards (1996) are consensus documents that can be used as starting points for NOS research if science education researchers will agree to take them seriously. This is the main point of this paper. There may be other ways to achieve reasonable consensus on the nature of science, but these two reform documents are widely known and extensively used by the science education community. They offer a good opportunity for NOS researchers to achieve greater agreement among themselves regarding the complex nature of the natural sciences.

The development and field test of the 28-item 'Ideas on Natural Science' (INS) questionnaire reported in this paper are a step toward taking seriously Benchmarks and Standards as a foundation for NOS research. The low reliability of the INS instrument suggests

that much work remains on developing an instrument that is both valid and reliable. Rather than sift back over the results of the INS field test, we want to conclude this paper with some observations and recommendations directed to NOS researchers and others interested in assessing students' ideas on the nature of the natural sciences.

1. Be careful not to confuse ideas on science with attitudes toward science. Lederman et al. (1998) make this point and we want to underline the importance of restricting NOS research to ideas on science.

2. Identify subscales or groupings within a NOS instrument that, together, define NOS literacy. The 7 categories we identified in our 28-item 'Ideas on Natural Science' questionnaire are not the only areas that might be needed to define NOS literacy. Reasonable agreement on both groupings and items is needed to be able to compare data sets among researchers.

3. Supplement paper-and pencil data with interview data. This recommendation is not new but it seems that few researchers follow it. Our experience has shown that students often interpret an item in ways that were not anticipated by the researcher.

4. Consider science content-specific NOS research as a way to improve, or perhaps enrich, current efforts. In This Is Biology (1997) Ernst Mayr observes that biology, and in particular evolutionary biology, differs fundamentally from the physical sciences. Rather than NOS perhaps we should consider nature of biology, nature of physics, and so on. Teaching about

Evolution and the Nature of Science (1998) by the National Academy of Sciences raises questions that suggest NOS research should be tied closely to content-specific science.

Finally, we want to emphasize the importance of staying close to science content. Many of the disagreements among academics on the nature of science can be traced to misunderstandings of science content itself. The recent 'science wars', based on physicist Alan Sokal's parody "Transgressing the Boundaries: Toward a Transformational Hermeneutics of Quantum Gravity" published in the fashionable cultural studies journal Social Text , is basically a battle between those (natural scientists) who understand the content of science and others (social scientists) who have a much thinner grasp of science (see Sokal & Bricmont,1998, for more details). Benchmarks and Standards both take science content seriously as does Teaching about Evolution and the Nature of Science. Staying close to the content of science rather than the 'science-as- politics' viewpoint is, in our opinion, the preferable path for NOS researchers.

References

American Association for the Advancement of Science. (1990). *Science for All Americans*: New York: Oxford University.

American Association for the Advancement of Science. (1993). *Benchmarks for Science Literacy*. New York: Oxford University.

Kuhn, T. (1962). *The structure of scientific revolutions.* Chicago, IL: University of Chicago.

Lederman, N., McComas, W., & Matthews, M. (Eds.). (1998). The nature of science and science education: Part 2. *Science & Education*, 7, 507-642.

Lederman, N., Wade, P., & Bell, R. (1998). Assessing understanding of the nature of science: A historical perspective. *Science & Education*, 7, 595-615.

Mayr, E. (1997). *This is biology*. Cambridge, MA: Harvard University.

Munby, H . (1983). *An investigation into the measurement of attitudes in science education.* Columbus, OH: SMEAC Information Reference Center.

National Academy of Sciences (1998). *Teaching about evolution and the nature of science*. Washington, DC: National Academy.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy.

Sokal, A. & Bricmont, J. (1998). *Fashionable nonsense: Postmodern intellectuals' abuse of science*. New York: Picador USA.

Appendix A

Ideas on Natural Science

Do you agree or disagree with the following statements about the natural sciences? On the response sheet circle agree or disagree and explain why you believe your position is correct.

1. Natural science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study.
2. Scientists are confident they can discover patterns in all of nature.
3. Scientists assume that the universe is a vast single system in which the basic rules are the same everywhere.
4. The modification of ideas, rather than their outright rejection, is the norm in the natural sciences.
5. Scientists assume that even if there is no way to secure complete and absolute truth, increasingly accurate approximations can be made to account for the world and how it works.
6. Continuity and stability are as characteristic of science as change is, and confidence is as prevalent as tentativeness.
7. There are many matters that cannot usefully be examined in a scientific way.
8. Within a field of natural science (e.g., biology, chemistry, physics) there are common understandings about what constitutes an investigation that is scientifically valid.
9. There is no fixed set of steps that scientists follow that leads them to scientific knowledge.
10. Sooner or later, the validity of scientific claims is settled by referring to observations of phenomena.
11. Experimentation, where just one condition at a time is varied, is not possible in some areas of the natural sciences.
12. A hypothesis that cannot in principle be put to the test of evidence is not scientifically useful.

13. Inventing ideas about how the world works is just as creative as writing poetry or composing music.

14. Theories in science must be logically or mathematically sound and use a significant body of valid observations.

15. Scientists usually work alone as they try to understand the natural world.

16. Scientists are less likely to be biased in public matters than are other members of society.

17. The vast majority of scientists stay within the bounds of ethical professional behavior.

18. The purposes of science and technology are about the same.

19. Change and continuity are persistent features of science.

20. Supernatural explanations of natural phenomena have no place in science.

21. Knowledge of nature generated by natural scientists is no more reliable than other knowledge.

22. The word "theory" in science means a hunch or a guess about how some part of the world works.

23. Laws in science are not subject to change.

24. Scientists have less interest in the fine arts than people in other professions.

25. A scientist is more willing to change her mind when new evidence appears than are other people.

26. Only by doing carefully controlled experiments can scientists learn about our world.

27. Most scientific discoveries are useful to people.

28. The validity of scientific knowledge depends heavily on the beliefs and customs of the country in which the scientists live.

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